Assessment of executive functions in patients with obsessive compulsive disorder by NeuroVirtual Reality

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Abstract. Executive functions are often impaired in obsessive compulsive disorder (OCD). We used a Virtual Reality (VR) version of the Multiple Errand Test (MET) inside a virtual supermarket, in order to evaluate the executive functions in daily life in 10 OCD patients and 10 controls. It is performed in a shopping setting where there are items to be bought and information to be obtained. The specific goal of this study was to implement a tool for the assessment of executive functions.

Keywords. Virtual Reality, Multiple Errands Test (MET), Executive functions, Obsessive-compulsive Disorder

Introduction

The executive functions are a set of mental processes which include problem solving, planning, working memory, inhibition, mental flexibility, initiation and monitoring of actions. Deficits in these functions are called "dysexecutive syndrome" and they are common in neurological patients with frontal lobe damage due to traumatic brain injury or stroke [1]. Individuals who have an impairment of executive functions show problems of starting and stopping activities, a difficulty in mental and behavioral shifts, an increased distractibility and difficulties in learning new tasks [2]. This syndrome may be present in different clinical disorders, such as dementia, attention and hyperactivity disorder, schizophrenia [3] and obsessive compulsive disorder.

Obsessive compulsive disorder is a psychiatric condition which is characterized by recurrent, intrusive thoughts, impulses and images, often associated with compulsive behaviors that are repetitive, time consuming and often ritualized [4].

From the neuropsychological point of view, patients with obsessive compulsive disorder (OCD) show deficit of executive functions, which are characterized by the

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impairment of several skills such as attention, planning, problem-solving and behavioral control [5]. Further, OCD is often associated with impairments of visuospatial skills [6], and of memory functioning, including visual, verbal, and numerical [7].
According a recent review [8], the executive functions which seem to be representative of the perseverative and repetitive behaviours observed in patients with OCD are set-shifting and response inhibition. Set-shifting refers to the ability to shift attention among different features of a stimulus in response to a changing feedback.
The assessment and the rehabilitation of executive functions under typical clinical or laboratory conditions are unsatisfactory for several reasons. In such settings, planning, multi-tasking or problem solving are usually assessed by pen and paper tasks rather than being presented in an actual or simulated way [9]. Increasing the ecological validity of neuropsychological assessment is important since this will increase the likelihood that patient's cognitive and behavioural responses will replicate the response that would occur in real-life situation [10].
The Multiple Errands Test (MET) developed by Shallice & Burgess [2], is instruments used to assess executive functions in real life settings; it consists of tasks abide by certain rules. It is performed in an actual shopping mall-like setting where there are items to be bought and information to be obtained.
Recent research shows that Virtual Reality can offer new possibilities for the assessment of executive functions providing an additional support to the traditional paper and pencil tasks [11, 12].
The present study is aimed at analyzing the executive functions in patients affected by obsessive compulsive disorder through a neuropsychological battery and a Virtual Reality (VR) version of the Multiple Errands Test (MET) [13, 2] based on the NeuroVR software, as proposed by the Applied Technology for Neuropsychology laboratory, Istituto Auxologico Italiano of Milan [14].

Methods

We recruited 10 patients suffering from obsessive compulsive disorder diagnosed according to DSM IV-TR criteria (M=6, F=4; mean age=32,8 years, std.dev.=10,8) and 10 healthy controls (M=6, F=4; mean age=37,2 years, std.dev.=8,3) (table 1). Patients were randomly selected from the outpatient Unit of Psychiatry of Palermo Universitary Hospital.

Table 1: Population characteristics

	Experimental group	**Control group**
	n = 10	*n* = 10
Age (Mean ± SD)	32,80 ± 10,779	37,20 ± 8,324
(range)	19 ± 53	28 ± 53
Gender (M, F)	6, 4	6, 4

Patients were excluded from the study if they had a severe cognitive impairment (MMSE<19), a severe motor impairment which did not allow subjects to perform the

procedure, auditory language comprehension difficulties (Token Test<26,5), object recognition impairments (Street Completion Test<2,25), excessive state and trait anxiety (STAI>40) and excessive depression state (Beck Depression Inventory>16).
The control group consisted of subjects without motor and cognitive impairments. In particular, exclusion criteria were: cognitive deficit evaluated by MMSE (cut off: 24); motor impairment which does not allow subjects to perform the virtual procedure; sensory deficits.
We used a complete neuropsychological battery for the assessment of executive functions, in the experimental group, including: Frontal Assessment Battery-FAB, to assess the presence and the severity of a dysexecutive syndrome affecting both cognition and motor behavior; Trail Making Test (form A and B), to investigate the visual attention and task switching; Phonemic and Semantic Fluencies, for object denomination; Tower of London, for the capacity of planning, and Corsi's memory span and supra-span, Digit span, Short Story recall and word recall tests, for memory evaluation.
After a neuropsychological evaluation, we used the Virtual Multiple Errands Test (V-MET), both in cases and in controls. In this version, after a training session, the subjects were requested to select and to buy various products presented on shelves with the aid of a joy-pad.
In particular, subjects were invited to buy some items following a defined shopping list (e.g. a chocolate bar or a product in sale) and to obtain some information (e.g. the closing time of the supermarket) following specific rules:

- you must complete all tasks but you can choose any order;
- you are not allowed to enter any aisle unless you need items to complete part of your task;
- you are not allowed to go into the same aisle more than once;
- you are not allowed to buy more than two items for item category;
- take as little time as possible to complete this exercise without rushing excessively;
- do not speak to the person observing you unless this is part of the exercise.

While completing the Multiple errands test procedure, time of execution, total errors, partial tasks failures, inefficiencies, rule breaks, strategies and interpretation failures were measured.

Results

We applied the *Mann-Whitney Test* to evaluate the performance differences at the virtual test (V-MET) among cases and controls. The execution time for the whole task was higher in patients with OCD compared to controls, suggesting that patients with OCD need more time in planning than controls. The same difference was found in the partial errors during the task; in particular, there was a significant difference in the mean rank of the partial errors for the sub-tests 6 (buying two products from the refrigerated products aisle, Asym. Sig. = 0.025) and partial errors 7 (going to the beverage aisle and asking about what to buy, Asym. Sig. = 0.024). Furthermore, the mean rank for inefficiency (Asym. Sig. = 0.08) and for interpretation failures is higher for controls (Asym. Sig.=0.01), while the values of divided attention (Asym. Sig.=0.02)

and the of self correction (Asym. Sig. =0.07) seems to be lower in controls. We think that obsessive patients tend to work with greater diligence and observance of rules than controls.
Among patients, Spearman correlation coefficients were used to examine the relationship between the neuropsychology tests and the scores of virtual version MET for each group (table 2).

Table 2. Correlations between neuropsychological tests and the variables of the virtual MET

	Errors 5		**Inefficiencies**		**Sustained attention**		**Maintained sequence**		**No Perseveration**	
	r	**p**	**r**	**p**	**r**	**p**	**r**	**p**	**r**	**p**
FAB			.628	.05						
TMT (B)	-.645	.04			.817	.00				
TMT (BA)	-.674	.03			.820	.00				
Phonemic Fluencies									.671	.03
ToL			.736	.01			-.772	.00		
Digit Span									.688	.02
Corsi's mem.span			.789	.00						
Corsi's supra-span			.859	.00						

The Frontal Assessment Battery correlates with the inefficiencies variable (Sig.=0.05); the Trail Making Test significantly correlates with some VMET's variables: sustained attention, partial errors in performing of task n. 5 (buying a product on sale); the Fluence Phonemic correlates with the absence of perseveration; the Tower of London correlates with inefficiency and with maintenance of the tasks sequence; the Digit span correlates with the absence of perseveration; the Corsi's memory span and the Corsi's supra span correlates with the inefficiencies.

Conclusions

Our results provide initial support for the feasibility of using the VMET as an assessment tool of executive functions.
Further, the significant correlation found between the VMET and the neuropsychological battery support the ecological validity of VMET as an instrument for the evaluation of executive functions in patients with OCD.
The results of the present study are limited by the small sample size. Further studies are needed to clarify the relationship between traditional tests and the emerging tools based on virtual environment. For these purposes, analyses of comparable samples of OCD subtypes (e.g. washers, checkers, gamblers) could be relevant because the heterogeneity of the disorder can lead to different results for each subtype.

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